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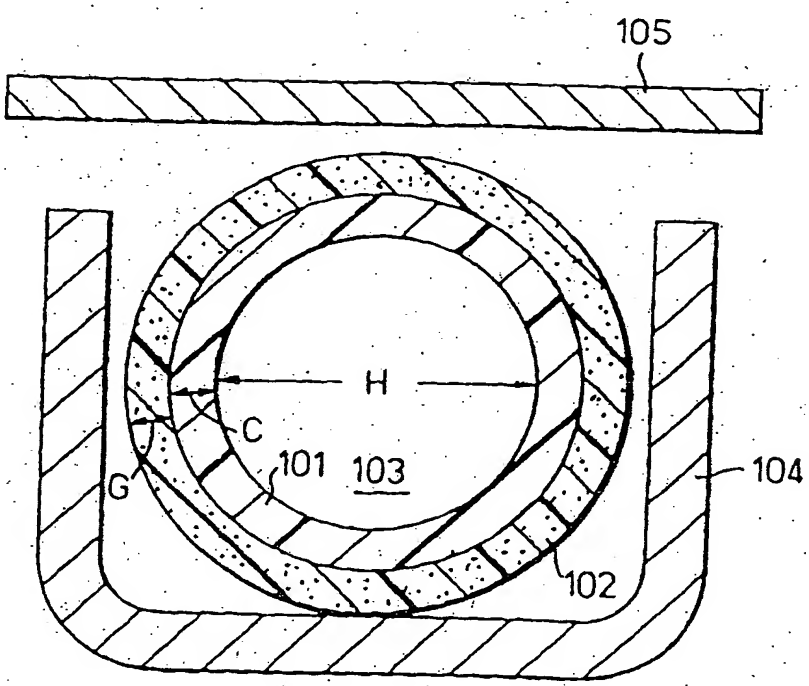
(57) Abstract

Sealant profiles comprising an elongate tubular or filamentary flexible carrier (60) carrying mastic or pressure-sensitive adhesive sealant material (61), the profile being suitable for location in tongue-and-groove joints or other structures where sealing between adjacent bodies (64, 65) is desired. The profile may have a projection (62) integral with the carrier for attaching the profile to a body to be sealed, for example by location of the projection in a suitable slot (63) in the body.



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SEALANT-CARRYING ARTICLES

This invention relates to elongate sealant-carrying articles (hereinafter "sealant profiles") of various cross-sectional shapes, which may be useful in a wide variety of circumstances for sealing against and/or between surfaces.

One aspect of the invention provides a free-standing article comprising a tubular body of mastic or pressure-sensitive adhesive (PSA) material (both or either hereinafter referred to as "sealant material") carried by an internal (to the tubular body) flexible (preferably resiliently-flexible) gas-containing carrier.

It will be understood that PSA "sealants" may be better adapted for fastening applications by virtue of their specifically designed adhesion properties, although use of PSA-carrying profiles according to this invention for partly or entirely sealing purposes is not excluded. Mastics are normally used only for their sealing characteristics, derived from their well-known cold flow and void-filling properties.

In all aspects of this invention, the mastic sealant materials may be selected from known mastics, for example bitumen-based compositions or blends of ethylene/vinyl acetate copolymer with polyisobutylene, and the PSA sealant materials may be selected from known PSAs, for example styrenic block copolymers, acrylic copolymers, tackified rubbers, or silicones, having whatever levels of tack and adhesion strength may suit the desired end use requirements.

The shape of the carrier is not critical, square or hexagonal profiles, for example, being feasible, although substantially circular or oval shapes may often be preferable, and the same applies to the tubular profile of the sealant.

Preferably, the carrier is also tubular, for example a rounded, more preferably a substantially circular tube, which is also the preferred form for the tubular body of

sealant. However, the carrier may also be a solid or tubular body of foamed polymeric material, preferably having open foam cells, or such a foam might be present on the outer surface of a solid carrier, preferably a solid-walled tube carrier, and/or within the bore of a solid-walled tube.

It will be understood that the provision of a tubular body of sealant material on a carrier as specified can enable a relatively small volume of sealant to seal a relatively large space, which is advantageous when expensive sealants are required. The specified use of a gas-containing flexible carrier, preferably a flexible tube and/or foam, has the further advantage that the sealant can be deformed by compression, to make good contact with the surfaces to be sealed, using considerably less force to deform the carrier (thus compressing or displacing the gas) than would be required to displace a solid body of sealant, or sealant on a solid carrier, in a confined space. The preferred use of a resiliently-flexible carrier has the additional advantage that the resilient recovery force of the deformed carrier can be used to maintain the sealant under compression against the surfaces to be sealed. For some purposes however, adequate seals may be formed with very slight compression of, or possibly mere contact with, the tubular body of sealant.

The invention accordingly includes the article when positioned on a first body, preferably in a channel formed in the first body, which is capable of receiving a portion of a second body to form a seal between the first body and the second body, preferably with compression of the article. The channel in which the article may be placed may be of any shape to match the shape of the article. However, mathematical modelling indicates that desirable stress distributions may be achieved when the article, preferably of the preferred rounded or substantially circular shape, is positioned in an angular channel, preferably a substantially rectangular channel, in the first body, thus preferably forming a seal by compression of the article within a tongue-and-groove type connection between the first and second bodies.

The articles according to this invention may be especially useful, for example, in sealing joints in housings for electrical or other apparatus, e.g. cable splice casings for

telecommunications or other purposes, traffic sensor domes, gas meter casings, automotive lamp assemblies and mirror mountings, domestic appliances (e.g. condenser seals in tumble dryers, refrigerators), and in many other gasket or flange sealing arrangements. The article may be cut to length, and may when required be joined together at its ends to form a closed loop, e.g. by means of adhesives or by sliding the ends of a tubular carrier over a short coupling rod.

The invention accordingly includes a method of forming a seal between a first body and a second body comprising placing a article according to this invention in contact with a portion of the first body and bringing a portion of the second body into compressive contact with the article so as to compress the article between the first and second bodies. The invention also includes a housing component for electrical or other apparatus the housing component carrying a article according to this invention and the article being positioned on the housing component so as to be compressed and form a seal between the housing component and another body with which the housing component will be assembled in use. Preferably, the housing component will carry the article in a channel arranged to receive a mating part of the said other body in use to form a sealed connection, preferably a tongue-and-groove type of connection. The invention also includes the housing component and article when assembled together with the said other body to form the seal. Also included is a kit of parts comprising the housing component and the article capable of being positioned thereon and assembled with the said other body as aforesaid. Such a kit may also include the said other body, preferably a second housing component, capable of assembly together with the said housing component to compress the said article to form a seal between the said housing component and the said other body.

In preferred articles according to this invention, the sealant material has been applied to the carrier by solution coating, especially as known per se for PSAs, or by melt coating, preferably under elevated pressure, and preferably with at least a surface region of the carrier being or becoming molten or softened while in contact with the molten sealant material. Application of molten sealant, especially under pressure, or solvent

coating using solvents which soften or swell the surface of the carrier, tends to enhance the adhesion of the sealant to the carrier. The adhesion tends to be further enhanced by the preferred melting or softening of at least the surface of the carrier, since this will tend to form an intermingled or enhanced-contact bondline region. Good adhesion is especially desirable when the preferred sealant sealants are used, since the coherent strength of the sealants will then tend to promote clean removal of the sealants from the sealed surfaces on separating them to obtain re-entry to a sealed housing or other device, as is often required in practice. Thus, it is preferred that the adhesion strength of the sealant material to the carrier is greater than its adhesion strength to a body with which it is to be placed in sealing contact in use. Usually, it will be preferable for the adhesion strength of the sealant to exceed its cohesive strength, so that its bond to the carrier and/or to another surface will fail cohesively.

Enhanced adhesion may be achieved when the carrier is an extruded article and the sealant material has been applied during or immediately after the extrusion of the carrier, preferably by co-extrusion with the carrier. However, it is also possible to extrude the sealant material onto a pre-formed carrier, for example using known kinds of apparatus used for extruding polymer insulation onto electrical wires. Good adhesion may still be obtained, for example by pre-heating the carrier and/or by selecting suitably compatible materials for the carrier and the sealant. Primers and/or bonding agents may also be used to enhance adhesion. Cooling of the extruded sealant layer by feeding the extruded article through a water bath has been found surprisingly effective in producing satisfactory articles for subsequent end use.

The invention accordingly includes a method of forming a article according to this invention, comprising applying a tubular layer of the said sealant material to the said carrier either in solution, followed by removal of the solvent, or in a molten state and causing or allowing the applied sealant material to solidify. The molten state method preferably involves extruding the carrier and applying the sealant material thereto during or immediately after the extrusion of the carrier, preferably by co-extrusion with the carrier, but may instead comprise extruding the sealant material onto a pre-formed carrier,

preferably after warming the carrier surface. Suitable processing equipment and conditions will readily be selected by those familiar with such matters.

Compatible materials to achieve desirably high levels of adhesion may be selected by trial and error. Preferred materials for at least the outer surface region (preferably for the whole) of the carrier in some cases include materials composed of, or comprising as a majority component, ethylene/vinyl acetate copolymer containing less than 40%, preferably less than 20%, by weight of vinyl acetate, ethylene/alkyl (preferably methyl) acrylate copolymer containing less than 40%, preferably less than 20%, by weight of alkylacrylate, or polyethylene, preferably low-density polyethylene. Alternatively, for example for the preferred resiliently-flexible carriers, elastomer materials, preferably thermoplastic elastomer materials, especially olefinic elastomers, are desirable, examples of which include (a) very low density polyethylene (VLDPE) plastomer, e.g. Dow Plastics' Engage CL8001 (Trade Mark), which is believed to be a metallocene-catalysed polyolefin elastomer of ethylene with 25% octene co-monomer; (b) polyether/polyester block copolymer, e.g. DuPont's Hytrel (Trade Mark) softer, lower-melt-viscosity grades such as G4074; and (c) polypropylene-based elastomer, e.g. DSM's Sarlink 3140 (Trade Mark), which is believed to be a polypropylene/EPDM blend having a Shore A hardness (5 seconds) of 42 (extruded) to 49 (injection moulded).

The sealant material is preferably thermoplastic, although crosslinked or thermoset sealants are not excluded.

Specific embodiments and end uses of this aspect of the invention will now be described by way of example, with reference to the accompanying drawings, wherein:-

Figure 1 shows a schematically in perspective a possible hexagonal sealant profile on a square carrier;

Figure 2 similarly shows a possible square sealant profile on a round tubular carrier having a foam coating on its outer surface;

Figure 3 shows schematically a tongue-and-groove joint containing the preferred round tubular article of the present invention, in comparison with a round solid body of sealant in a similar joint;

Figure 4 similarly shows the preferred article in comparison with a solid body of sealant in a simple overlap joint;

Figure 5 shows the preferred article in a possible confined abutment compression arrangement;

Figure 6 shows schematically in perspective a moulded plastics sleeve housing for enclosing telecommunications cable splices, the housing having a longitudinal tongue-and-groove edge closure;

Figure 7 shows a schematic end view of the tongue-and-groove closure of Figure 6 before and after closing with the preferred article in the groove;

Figure 8 shows schematically in sectioned perspective a two-part housing with tongue-and-groove joint sealed by the preferred article; and

Figure 9 shows schematically in cross-section a side elevation of an automotive headlamp housing incorporating the article.

Referring to the drawings, Figure 1 shows a square carrier strip 11 of foamed polymer over which has been extruded a tubular coating of sealant 12 having a hexagonal outer profile.

Figure 2 shows a carrier comprising an extruded hollow tube of ethylene/vinyl acetate (EVA) copolymer 20, having a substantially concentric outer layer of foamed

polymer 22 (formed by known methods), over which has been formed a tubular layer of sealant 24 having a square outer profile.

Figure 3A shows an end view of a preferred article having a round tubular carrier 30 of extruded thermoplastic elastomer having a substantially concentric tubular layer of sealant 32 co-extruded thereon, in a channel 34, which might in practice be formed in a main surface or an edge of a body to be sealed. Figure 3B shows an edge portion 36 of a second body introduced into the channel 34 to form a tongue-and-groove joint, thus easily compressing the hollow article and causing the sealant to seal the joint. The arrangement shown in Figure 3A could also be used to form a seal against a surface of a second body laid across the top of the channel 34 so as to compress the article therein. The resilience of the preferred thermoplastic elastomer carrier tends to maintain the sealant under compression against the sealing surfaces, thus compensating for thermal expansion and contraction to maintain the seal.

For comparison, Figures 3C and 3D show a corresponding tongue-and-groove joint with a solid body 38 of sealant. In the absence of the gas incorporated in the carrier of the present invention, the solid sealant is substantially incompressible and therefore requires much higher forces to distort and/or displace it on formation of the joint. Relatively small areas of sealing contact may result, and the seal-maintaining effect will depend on the resilience of the sealant itself, thus limiting the choice of sealants and possibly not providing sufficient seal maintenance with some materials.

Figures 4A and 4B show the preferred article 40, similar to that of Figure 3, between overlapping joint surfaces 42, 44. Figures 4C and 4D illustrate a corresponding joint using a less compressible solid body 46 of sealant, with disadvantages similar to those described for Figure 3.

Figure 5A shows the preferred article 50, similar to that described for Figure 3, in a hypothetical stepped butt joint formed by components 52 and 54. Even in such a confined sealing space, the gas-containing carrier of the present invention permits

relatively easy compression of the article to form a seal as indicated schematically in Figure 5B. This could be extremely difficult with a solid body of sealant, owing to the shortage of space to take up the distortion of such a substantially incompressible solid body.

Figure 6 shows in perspective a moulded sleeve housing 60 designed for enclosing splices in electrical and/or optical telecommunications cables. The cables (not shown) enter and leave through entry and exit ports in end pieces known per se (not shown) and the sleeve 60 is wrapped around the end pieces to enclose the splices in the parts of the wires or optical fibres (not shown) which lie between the end pieces. The sleeve 60 is then closed by means of a projection or tongue 62 and groove or channel 64 extending along its opposed edges. As shown schematically in more detail in Figure 7A, the channel 64 has positioned therein a article 66 according to this invention. On insertion of the projection 62 into the channel 64, the article 66 is compressed to form a sealant seal as shown in Figure 7B. A locking clamp 68, of generally channel-like configuration, is slid on lengthwise from the end of the tongue and channel formations to hold the joint together (Figure 7B). Snap-fit or other fastenings could be used if desired.

Figure 8A shows schematically in perspective a section of a simplified two-part housing such as might, for example, contain the working parts of a gas or electricity meter. The top part 80 (as illustrated) has a projecting tongue 82 designed to fit into a corresponding slot or channel 84 in the lower part (as illustrated) 86. The channel 84 contains a tubular article 88 according to the present invention, which is compressed to form a sealant seal on assembly of the tongue-and-groove joint in the housing, as illustrated in Figure 8B. Of course, many different shapes and arrangements of such housings occur in practice to suit the needs of the particular gas meter or other equipment to be enclosed, and all may be sealed by one or another of the article configurations according to this invention.

Figure 9 shows a headlamp housing comprising a moulded polypropylene backshell 90 having a rear aperture 92 to receive the lamp bulb mounting and a circumferential

channel 94 containing a article 96 according to the present invention, which has been cut to the required circumferential length and joined together at its ends to lie securely in the channel 94. The headlamp lens 98 has a projecting circumferential lug or tongue 100 designed to fit into the channel 94 thus compressing the article 96 to form a sealed tongue-and-groove joint. Retaining clips or other means (not shown) may be used to secure the lens 98 and backshell 90 together.

The provision of the tubular body of sealant on a carrier according to this invention enables the article to be produced in long continuous lengths for laying into channels or other sealing locations in whatever lengths are usually required.

The relative diameters and wall thicknesses of the tubular body of sealant and the carrier are not critical, and may be selected to suit specific end uses, bearing in mind that smaller carrier diameters may tend to limit the advantageous deformability of the articles. Where foams are used in the carrier, higher density foams may also tend to limit the compressibility of the articles, but the choice may otherwise be freely made to suit practical needs. It may be desirable in many cases to use a sealant coating whose radial thickness is less than 0.5 times, preferably less than 0.25 times the carrier outer radial dimension. For circular carriers and sealant tubes, in other words, the thickness of the tubular sealant layer may usefully be less than one third, preferably less than one sixth, of the outer radius of the sealant tube. The carrier wall thickness (for hollow tubular carriers) will preferably be not less (often considerably greater) than the sealant thickness, but thicker layers of mastic sealant may be useful in some circumstances, e.g. for void filling. Variations from, and within, these preferred ranges of radii and/or wall thicknesses may be selected to suit particular requirements. Overall diameters ranging from a few millimetres to a few centimetres, preferably 0.25 cm to 3 cm, especially 0.5 cm to 2 cm, are likely to be useful in most cases.

For avoidance of doubt, the term "tubular" as used herein is to be understood as including any elongate hollow body resembling a pipe or conduit, regardless of its cross-sectional shape.

One may add to the above the use of polysiloxane elastomeric material to enhance resistance to compression setting of the articles. This enhancement may be achieved by using the polysiloxane elastomer material (or a blend of polymers containing it) as the internal carrier according to the aforementioned application. In this case, the adhesion of the sealant to the carrier may require enhancement, either by means of primer coatings or by provision of fibrous layer surrounding, preferably gripping, the carrier. The sealant, if sufficiently cohesive, may be able to form a tube surrounding the carrier with little or no adhesion to it.

Alternatively, the aforesaid enhancement may be attained by placing the polysiloxane elastomer material or blend inside a tubular internal carrier made of another material. In this case, the tubular carrier may act as a sleeve fitted over a member formed from the polysiloxane elastomer, which may itself be in the form of a hollow tube of circular or other profile, or may be in the form of a foam.

Suitable methods for forming the articles including the polysiloxane elastomers will readily be selected in general from known co-extrusion and other coating and/or moulding techniques.

It has also been discovered that, when the carrier itself is tubular with a hollow bore, the bore diameter is preferably not more than 60% (and not less than 5%, preferably not less than 10%, of the total outside diameter). The remaining 40% of that diameter is made up of the tubular carrier and the tubular sealant on the outside surface of the carrier. It has interestingly been found by mathematical modelling that with "thick" sealant layers (that is, layers whose thickness is greater than the thickness of the carrier), the sealant characteristics dominate, so that changes in the hardness of the carrier material have relatively little effect on the compression forces required to distort the article in a "channel-and-lid" sealing arrangement, as illustrated in the accompanying drawing. When "thick" carriers (thicker than the sealant layer) are used, the carrier hardness tends to dominate the compression force, which is relatively unaffected by changes in the sealant

hardness. When the sealant and carrier are of approximately the same thickness as each other, it has been found that a pair of "thick" layers (each of thickness greater than 10%, preferably greater than 15%, of the overall diameter) tend to be dominated by the sealant hardness, whereas a pair of "thin" layers (each of thickness less than 10% of overall diameter) tend to be dominated by the carrier hardness. These findings are especially applicable to the generally useful range of sizes around 10 mm overall diameter for substantially round tubes, and are likely to be preferred for diameters ranging from 2 to 30 mm, preferably 5 to 20 mm.

These aspects of the invention are further illustrated by the accompanying drawings wherein Figures 10 and 11 show schematically a tubular sealant profile in a channel-and-lid sealing arrangement.

In the drawings, Figure 10 shows schematically a article according to the invention having a polysiloxane elastomer carrier 101 carrying a tubular coating of sealant 102, the carrier and the sealant being of approximately the same thickness, and a substantially central substantially round hole 103. The diameter H of the hole 103 (not shown to scale) will be not more than 60% of the total outside diameter; which is equal to the hole diameter H plus twice the carrier thickness C and twice the sealant thickness G. This article is shown in a channel 104 onto which a lid 105 is ready to be pressed. Figure 11 shows the lid pressed into position on the channel, thus compressing the article and causing the sealant to form a seal against the lid and the sides and bottom of the channel. The pressure resistance of the seal tends to increase with increasing hardness of the carrier and/or the sealant, which also increase the compressive forces required to close the lid and deform the article.

Typical sealants might have a Voland hardness of 60 gms or 100 gm. Typical carrier materials might be Sarlink (Trade Mark) thermoplastic elastomer of Shore hardness 40, 60 or 80, or Thermolast (Trade Mark) thermoplastic elastomer of Shore A hardness 25.

Another useful form of article according to the present invention, derived from those hereinbefore described, is one whose tubular length is less than its largest outer diameter, preferably less than half, more preferably less than one quarter, of its largest outer diameter. Such articles may be regarded as rings (usually substantially circular, although other configurations are not excluded), which may have been formed by cutting from a longer length of the tubular article. Other methods of making such relatively short tubes or rings may be envisaged, but cutting from longer lengths is usually more convenient in practice. The expression "largest outer diameter" is intended to include shapes other than substantially circular.

These ring-like articles may advantageously be put to use as a gasket between opposed pressure surfaces, or as a grommet on an elongate object (e.g. a wire) passing through the article, especially where it is desired to seal a larger aperture through which the elongate member also passes, which aperture fits closely around the perimeter of the grommet provided by the ring-like article.

In another useful application of the present sealing technology, an elongate article as hereinbefore described may be arranged with one of its ends in endwise abutment with its own other end or with an end of another such article, wherein the said sealant material is present at both of the said abutting ends and seals them together, possibly by melt fusion of the sealant material and/or possibly without any additional means attaching the ends to each other. The sealant material (preferably sealant) has been found surprisingly effective in maintaining a seal between the abutting ends of articles arranged in a closed loop or circle when compressed in use in a channel-and-lid or tongue-and-groove sealing arrangement. Additional attaching means such as adhesives or a solid peg extending into an internal bore at the abutting ends may also be used if desired. A hollow attachment pin may advantageously transmit internal gas pressure across such an abutting end joint in a hollow tubular article.

In all forms of the articles herein described, it is possible that the perimeter of the tubular body of sealant material extends only partly around the carrier, thus forming an

open-sided tubular body of the sealant material. Such an open-sided tubular body would not include a flat sheet carrying a layer of the sealant material on only one of its main surfaces, but includes structures wherein the sealant material extends partway around the carrier rather than completely around it, and includes both rounded and angular open tubes, for example where the sealant extends partway (preferably more than halfway, more preferably more than three quarters of the way) around a round or elliptical carrier or around more than one side of an angular carrier, e.g. around three sides of a square or rectangular carrier.

In most forms of the various aspects of this invention, it will be preferable that the carrier is substantially continuous and substantially free of voids (meaning unintended voids).

Preferred forms of the articles for certain purposes are those wherein the carrier includes a formation, preferably integral with the carrier, for attaching the carrier to an object which is to carry the article in use. In these cases, although the carrier and the attaching formation could be completely enclosed by a coating of sealant (preferably sealant), it will frequently be preferable that the sealant encloses only the part of the carrier constituting its main body, which in use will perform the sealing function, leaving the attaching formation free of sealant. Thus, the partial enclosure of the carrier by the sealant hereinbefore referred to may be preferred in these cases. The attaching formation may take any appropriate form, one preferred form being a projection having an enlarged region receivable in use in an aperture in the said object to anchor the carrier thereto. The attaching formations need not be, but preferably are, integral with the carrier, the carrier and attaching formation preferably being moulded or extruded or otherwise formed as one piece. The attaching formation may itself be hollow, either as a continuation of a hollow tubular carrier or as a separate hollow body attached to the hollow carrier, or the attaching formation may be solid. Hooks or other convenient formations may be used for the attaching formation as desired, but the aforementioned projections with enlarged regions will often be convenient in use, especially those having an enlarged "head" which may be snap-fitted or slid into a slot in the object to which the article is to be attached.

Instead of or in addition to such an attaching formation, the carrier may carry an adhesive, e.g. the aforesaid PSA sealant, on part of its surface for the purpose of fastening the profile in a groove or channel or onto such other surface as may be desired in practice. Thus, a profile might comprise an elongate carrier having a fixing adhesive on part of its external perimeter and sealant, e.g. mastic or gel or adhesive (possibly the same as the fixing adhesive), on part or all of the remainder of its perimeter (as seen in end view).

These attachable aspects of the invention may provide articles which are especially suitable for long seals attached, for example, to objects such as windows or doors to provide seals at the closure interface, for example between the window frame and its casement. This may be particularly advantageous in double glazing constructions. The attaching projection or "lug" and/or the attaching adhesive will often extend all the way along the carrier, but may if preferred be provided only at intervals along it.

It will be appreciated that, instead of having an identifiable attaching formation or adhesive as described above, the sealing profiles according to this invention could simply be shaped as a whole and accommodated in a slot or aperture of appropriate shape to enable part of the profile to project for sealing purposes. Whatever the form of profile selected, the co-hesive strength, flexibility, and sealing characteristics of sealants, especially the preferred sealants hereinbefore mentioned, may be highly advantageous in circumstances requiring frequent re-opening and re-closing of the seals, for example doors and windows as aforesaid.

Articles according to this and other aspects of the invention may be useful, for example, for laying along surfaces of objects or in channels formed in objects to provide a sealant on or in those articles for sealing and/or fixing against other surfaces with which the articles will be in contact in use.

These further embodiments of the invention will now be illustrated by way of example with reference to the accompanying drawings, wherein:-

Figure 12 shows an O-ring seal cut from a tubular sealant article as hereinbefore described;

Figures 13 and 14 show in plan and transverse cross section respectively the use of an O-ring seal as shown in Figure 1 as a gasket in a pipe coupling;

Figure 15 shows in perspective the use of a small-diameter ring seal as a grommet on a wire passing through a conduit;

Figure 16 shows schematically a butt joint as hereinbefore described between tubular articles;

Figure 17 shows a tubular profile similar to that described above, with the addition of an arrow-headed projecting formation fixing the profile in a channel between two sealing surfaces; and

Figure 18 shows a profile comprising a generally triangular hollow carrier completely enclosed by sealant positioned in a groove shaped to retain the profile in one of a pair of sealing surfaces with part of the profile projecting from the groove to perform the sealing function.

Referring to the drawings, Figure 12 shows a tubular article having a tubular carrier 50 and an outer coating of sealant 52 adhering to the outer surface of the carrier as described in the first two aforementioned co-pending applications. A thin ring 54 is shown having been cut from the tubular member for use as a gasket or grommet as hereinbefore described.

In Figures 13 and 14, a coupling between two sections of pipe 60 and 62 is schematically shown using a gasket O-ring 54 generally similar to that illustrated in Figure 12. The gasket 54 sits on a step formed in the end of pipe section 62 and is compressed when the section 62 is assembled with interlocking section 60. The transverse cross-sectional view of Figure 14 is taken on the line 3-3 of Figure 13.

Figure 15 shows a grommet 80, which is essentially a smaller-diameter version of the O-ring shown in Figure 12, fitted on an insulated electrical wire 82 passing through a

transparent conduit 84, against which the outer sealant coating of the grommet 80 makes a seal. The resilient carrier 86 of this grommet fits tightly around the wire 82.

Figure 16 shows schematically a butt end seal 90 between tubular article ends 92 and 94 within a schematically-indicated groove or channel 96 of a channel-and-lid or tongue-and-groove sealing arrangement. Sealant sealant carried on the tubular carriers of the articles 92 and 94 is indicated schematically at 98 and seals the abutment 90 between the ends.

Figure 17 shows another form of profile in which the sealant 71 adheres to a hollow carrier 70 having an arrow-headed fixing lug 72 engaged in slot 73 of a first body 74 mateable with a second body 75 so that the article can perform its sealing function. The mateable bodies 74 and 75 may for example be protective housing parts for enclosing electrical or other equipment, for example wire or cable joints, optical fibre joints, or gas meter working parts, or may be door or window closure members as hereinbefore mentioned. The materials for the carrier and sealant may be selected for convenient manufacture and to suit the end uses in question, the sealant preferably adhering reasonably strongly to the carrier in this form of article. Preferred materials are those mentioned in the aforementioned co-pending applications, the disclosures of which are incorporated herein by reference.

In Figure 18, a triangular rod-like hollow resilient carrier 40, completely enclosed by sealant 41, has been forced-fitted or longitudinally slid into groove 42 formed in one of a pair of mating bodies 43, 44 (for example protective housings or closure members as aforesaid). A portion 45 of the more-or-less triangular profile projects from the groove 42 so as to form a sealant seal against the mating surface 44 in use. The groove 42 has been shaped as shown to allow space for distortion of the profile under sealing pressure.

Another aspect of the present invention provides an article comprising a free-standing elongate tubular, filamentary, or rod-like carrier carrying an elongate body of mastic or PSA sealant material which encloses at least 50%, preferably more than 75%,

more preferably substantially all, of the perimeter of the carrier as viewed in transverse cross-section.

It will be understood that the reference to the view of the carrier in transverse cross-section means that the sealant encloses the stated proportions of the perimeter of the carrier as viewed from an end of the article looking along its longitudinal axis. The perimeter enclosed by the sealant is thus the perimeter of the cross-section. Substantially complete enclosure of that perimeter of the carrier by the sealant is advantageous for many purposes, and may obviate the need for the sealant to adhere, or at least to adhere strongly, to the carrier, since the cohesive strength of the sealant surrounding the carrier may be sufficient to retain it in on the carrier without such adhesion. For other purposes, however, partial enclosure of the carrier by the sealant may be preferable, for example when the carrier has a projection for fastening it to other objects as hereinafter described.

The cross-sectional shape of the carrier and that of the sealant are again not critical for the purposes of this invention. Square, triangular or other shapes, or even irregular shapes, may be used for the carrier and/or the sealant if desired or necessary, but substantially oval or round cross-sectional shapes will often be preferable for either the carrier or the body of sealant or both. For many purposes, it may be preferable that the carrier is a mono-filament of glass or plastics material, or a fibrous string or rope, which may be twisted or straight. The sealant may be applied to the carrier by any convenient method, and preferred articles according to this aspect of the invention are those wherein the body of sealant has been melt-coated, preferably extruded, around the carrier. In all aspects of this invention, the sealant may be cross-linked after placement on the carrier, although thermoplastic sealants on the carrier may be preferable for many purposes.

Articles according to this aspect of the invention may be useful, for example, for winding around other objects to provide a sealant surface thereon, or for laying along surfaces of articles or in channels formed in articles to provide a sealant sealant on or in those articles for sealing against other surfaces with which the articles will be in contact in use.

In most forms of the various aspects of this invention, it will be preferable that the carrier(s) is(are) substantially continuous and substantially free of voids (meaning random or unintended voids, not the aforementioned deliberately-formed through-holes). Preferred forms of the articles for certain purposes are those wherein the carrier includes a formation, preferably integral with the carrier, for attaching the carrier to an object which is to carry the article in use. In these cases, although the carrier and the attaching formation could be completely enclosed by a coating of sealant, it will frequently be preferable that the sealant encloses only the part of the carrier constituting its main body, which in use will perform the sealing function, leaving the attaching formation free of sealant. Thus, the partial enclosure of the carrier by the sealant hereinbefore referred to may be preferred in these cases. The attaching formation may take any appropriate form, one preferred form being a projection having an enlarged region receivable in use in the aperture in the said object to anchor the carrier thereto. The attaching formations need not be, but preferably are, integral with the carrier, the carrier and attaching formation preferably being moulded or extruded or otherwise formed as one piece. Hooks or other convenient formations may be used for the attaching formation as desired, but the aforementioned projections with enlarged regions will often be convenient in use, especially those having an enlarged "head" which may be snap-fitted or slid into a slot in the object to which the article is to be attached.

In this connection, another aspect of the invention provides an article comprising an elongate (preferably rod-like) carrier carrying an elongate body of sealant and including a formation, preferably integral with the carrier, or an adhesive as aforesaid, for attaching the carrier to an object which is to carry the article in use. Thus, relatively thick, rod-like carriers may be used, which may perhaps be regarded as unusually thick mono-filaments in the first embodiment of the invention hereinbefore described. Partial enclosure of the carrier by the sealant and possible use of partial adhesive layers may again be convenient for purposes similar to those aforesaid.

It will be appreciated that, instead of having an identifiable attaching formation as described above, the sealing profiles according to this aspect of the invention could simply be shaped as a whole and accommodated in a slot or aperture of appropriate shape to enable part of the profile to project for sealing purposes.

Specific embodiments of these aspects of this invention will now be described in more detail by way of example, with reference to the accompanying schematic drawings wherein :-

Figure 19 shows an end view of a profile comprising a mono-filament carrier completely enclosed by sealant;

Figure 20 shows a mono-filament profile similar to that of Figure 19 with the addition of an arrow-headed projecting formation fixing the profile in a channel between two sealing surfaces; and

Figure 21 shows a profile comprising a generally triangular rod-like carrier completely enclosed by sealant positioned in a groove shaped to retain the profile in one of a pair of sealing surfaces with part of the profile projecting from the groove to perform the sealing function.

Referring to Figure 19, a substantially round mono-filament carrier 10 of extruded ethylene/vinylacetate copolymer (known per se) carries a co-extruded coating 11 of a 6% triblock copolymer sealant composition of the kind described in the aforementioned publications. The sealant may be co-extruded onto the fibre or may be melt-coated onto a previously formed fibre. Suitable equipment and operating conditions can be selected without further instruction by those skilled in this field of technology, for example with the fibre-forming polymer being extruded from the main barrel of a cross-head extruder and the oil-extended triblock copolymer being melted in the cross-head and applied as an outer extruded envelope around the progressively-forming fibre.

Figure 20 shows another form of profile in which the sealant 61 adheres to a carrier 60 having an arrow-headed fixing lug 62 engaged in slot 63 of a first body 64 mateable with a second body 65 so that the article can perform its sealing function. The mateable

bodies 64 and 65 may for example be protective housing parts for enclosing electrical or other equipment, for example wire or cable joints, optical fibre joints, or gas meter working parts, or may be door or window closure members as hereinbefore mentioned. The materials for the carrier and sealant may be selected for convenient manufacture and to suit the end uses in question, the sealant preferably adhering reasonably strongly to the carrier in this form of article.

In Figure 21, the triangular rod-like carrier 70, completely enclosed by sealant 71 has been forced-fitted or longitudinally slid into groove 72 formed in one of a pair of mating bodies 73, 74 (for example protective housings or closure members as aforesaid). A portion 75 of the more-or-less triangular profile projects from the groove 72 so as to form a sealant seal against the mating surface 74 in use. The groove 72 has been shaped as shown to allow space for distortion of the profile under sealing pressure.

For all aspects of this invention, the sealant may in principle be extruded onto the carrier in a manner similar to that described with reference to Figure 19, with suitable modifications of the extrusion heads as will be apparent to persons skilled in such matters.

For avoidance of doubt, it is hereby confirmed that references herein to "free-standing" elongate articles carrying the sealant (sealant "profiles") are intended to exclude elongate components such as wires in a sealant-containing cable or other assembly. Such components are in contact with the sealant only as a result of being in that assembly and are therefore not free-standing sealant profiles in the present sense. It will be understood that the filamentary carrier of these free-standing profiles will often be a relatively narrow monofilament or a multi-filament yarn, preferably of diameter less than 3 mm, more preferably less than 2 mm or less than 1 mm. However, thicker carriers, for example of diameter 4 or 5 mm or more, possibly having more rod-like characteristics of stiffness, may also be useful. The profiles are generally preferred to be flexible and may be provided in coil or roll form from which the profile can be progressively unwound. In such coils or rolls, the sealant of the profiles in each succeeding layer may be in direct contact with that of the underlying layer, or a low-adhesion release sheet or other barrier

may be incorporated between the layers of sealant profile. The present application adds these clarifications and the present invention adds additional new aspects to the aforesaid pending application.

Preferably, the sealant articles comprising sealant carried on an elongate carrier are of sufficient flexibility to enable the article to be wound at least 90^0, preferably 180^0, around a circular shaft of diameter 100 cm, preferably 50 cm, more preferably 25 cm, especially 10 cm, without breaking the carrier. Various materials and forms of carrier will meet these criteria, one preferred variant using a carrier comprising a filament or yarn, preferably of glass, coated with plastics material of lower Young's modulus and/or higher elongation to break than the said filament or yarn. In such variants, it may be preferred that the carrier is a glass monofilament or multi-filament yarn coated with a polyolefin, preferably low-density polyethylene. For glass and/or other carrier materials, it may be preferred that the plastics material with which the filament or yarn is coated is one to which the sealant adheres more strongly than the sealant adheres to itself on surface-to-surface contact. The aforementioned low-density polyethylenes, especially after adhesion-enhancing surface treatments of known kind, tend to satisfy this criterion. The articles according to this aspect of the present invention are preferably made by feeding the carrier through an extrusion cross-head which melt extrudes the sealant onto the carrier in known manner.

Another aspect of the present invention provides the sealant profiles wherein the carrier comprises a spring, preferably a coil spring. The spring may be straight or bowed, eg. in the form of an uncoiled wire or leaf spring, but coil springs may be preferred for many purposes, for example where their longitudinal extensibility and/or lateral flexibility is useful. It may be desirable in some cases that the carrier is a coil spring and is embedded and enclosed in a solid body of the sealant which substantially fills the interior space of the coil. Alternatively, it may be preferred that the carrier is a coil spring and is enclosed by a hollow tube of the sealant, in which case it may be that the spring is at least partly embedded within the wall of the sealant tube. However the spring need not be embedded in the sealant wall of the tube, which may instead be like a

skin around the outer surfaces of the spring without the spring intruding to any significant extent into the (preferably uniform) thickness of the sealant wall. All these spring profiles have the advantage that the spring may be deformed to keep the sealant under compression to enhance the profile's sealing function in use. While springs made of plastics or other materials may be useful in some cases, it will often be preferable for the spring (of whatever form) to be made of metal. These spring profiles may be made by moulding the sealant around suitably short lengths of the spring carriers or by extruding it around longer carrier lengths fed through a suitable cross-head extrusion die.

In another aspect of the present invention the carrier of the sealant profile is a metal wire, with or without a plastics coating thereon. Preferably the bend modulus of the wire is sufficiently low for the article to be permanently bent without causing the wire to protrude through the sealant. The elongation of the sealant will usually be more than sufficient to accommodate such bending of the wire without cracking of the sealant. Suitable bend modulus of the wire is readily determined by testing whether the wire tends to cut through the sealant at the points where bending pressure is applied, any wire which does so preferably being rejected as too stiff for the selected sealant. The permanent bending of the wire enables this form of profile to hold an imposed bent shape without any unacceptable tendency to spring back into its undeformed shape or another undesired shape. These profiles may be made by continuous cross-head extrusion of a thermoplastic sealant onto the selected wire, or by moulding the sealant onto shorter lengths of wire in suitable moulds.

In another aspect of the present invention, the carrier of the profile is a stranded metal wire or rope, and in a fifth aspect, the carrier is a braid, knit, weave, or other fabric-like assembly of natural or synthetic filaments, preferably plastics or metal filaments. These forms of article may again be made by extrusion or moulding techniques similar to those referred to above.

Another aspect of the present invention provides use of self-anchoring profiles of the kind hereinbefore described as a bath seal or wash-basin seal; and a further aspect of

this invention provides use of the same self-anchoring profiles as a barrier to prevent moisture or other fluid from running down a sloping or vertical surface.

These aspects of the invention are further illustrated by the accompanying drawings, wherein :-

Figure 22 shows schematically a self-anchoring profile wash-basin seal, and

Figure 23 shows schematically a self-anchoring profile condensation barrier.

Referring to Figure 22, part of a wash-basin 10 is shown mounted in the usual aperture in a bench top 12, with a lip 14 of the basin projecting outwards across the bench top. Within the lip 14 is a tubular sealant profile 16 having a hollow (in this example) tubular carrier 18 attached to the bench top by integral securing lug 20 extending through a hole 22 in the bench top. The sealant profile, as is preferred, is wide enough to exclude water from the hole 22 in the event of water coming under the lip 14. The profile also prevents such water from running down between the bench top and the upright side of the wash-basin 10. The self-anchoring profile has the advantage of resisting the tendency to creep out of position which can be a problem with known injected sealing compounds.

Figure 23 shows schematically part of a car door 30 having an interior trim panel 32 attached by means of the usual metal spring clips 34 snap-fitted into apertures 36 in the painted metal door body. Vibrational movement of the clips 34 during the service life of the car tends to remove paint from around the apertures 36, thus exposing the underlying metal, which begins to corrode when condensation 37 runs down the inside of the door body beneath the trim panel 32 and reaches the exposed metal around the apertures 36. This problem may be addressed by securing a sealant profile 38 having a solid (in this example) carrier with attached securing lug 40 in suitable securing holes above those (36) of the trim panel, so as to intercept the condensation and divert it outwards away from the line of trim-securing holes 36. This diverting effect may be enhanced by sloping or curving the sealant profile, for example as shown by broken lines 38'. The diameter of the sealant profile 38 is wide enough to protect its own securing holes from the condensation, in a manner similar to that illustrated for the wash-basin of Fig. 22.

In all aspects of the present invention, the sealants may include additives such as cross-linking agents. Fillers and additives may also be used to increase the electrical and/or thermal conductivity of the sealants, or to enhance the noise or vibration-absorbing qualities of the sealants. Flame retardants, pigments, dyes, and other additives may also be used as desired, if compatible with the desired end-use properties of the sealants. The sealant surface may be chemically modified, for example selectively cross-linked, preferably using known cross-linking additives and/or initiators and/or heat and/or UV or electron beam radiation, to form a skin on desired parts of the sealant bodies and/or to reduce surface adhesion and/or to enhance the strength and/or handleability of the sealant bodies and/or to alter the chemical resistance of the sealant, for example to solvents or other fluids such as petrol (gasolene) with which the profile may come into contact in use, e.g. as a gasket.

CLAIMS:

1. A free-standing article comprising a tubular body of mastic or pressure-sensitive adhesive sealant material carried by an internal (to the tubular body) flexible (preferably resiliently-flexible) gas-containing carrier.

2. A article according to claim 1, wherein the carrier and/or the body of sealant material is tubular, preferably a rounded, more preferably a substantially circular, tube.

3. A article according to claim 1 or 2, wherein the carrier is or includes foamed polymeric material, preferably having open foam cells.

4. A article according to any preceding claim, positioned on a first body, preferably in a channel formed in the first body, which is capable of receiving a portion of a second body to compress the article thus to form a seal between the first body and the second body.

5. A article according to claim 4 positioned in an angular channel, preferably a substantially rectangular channel, in the first body.

6. A article according to claim 4 or 5 forming a seal within a tongue-and-groove type connection between the first and second bodies.

7. A article according to any preceding claim, wherein the sealant material has been applied in a molten state, and preferably under elevated pressure, to the carrier, preferably with at least a surface region of the carrier being or becoming molten or softened while in contact with the molten sealant material.

8. A article according to claim 7, wherein the carrier is an extruded article and the sealant material has been applied during or immediately after the extrusion of the carrier, preferably by co-extrusion with the carrier.

9. A article according to claim 7 wherein the sealant material has been extruded onto a pre-formed carrier.

10. A article according to any preceding claim, wherein the adhesion strength of the sealant material to the carrier is greater than its adhesion strength to a body with which it is to be placed in sealing contact in use.

11. A article according to any preceding claim, wherein at least the outer surface region of the carrier is composed of, or comprises as a majority component, an olefin copolymer, preferably ethylene/vinyl acetate copolymer containing less than 40%, preferably less than 20%, by weight of vinyl acetate, ethylene/alkylacrylate copolymer containing less than 40%, preferably less than 20%, by weight of alkylacrylate, or polyethylene, preferably low-density polyethylene.

12. A article according to any of claims 1 to 10, wherein at least the outer surface region of the carrier is composed of, or comprises as a majority component, elastomer material, preferably thermoplastic elastomer material.

13. A article according to claim 12, wherein the elastomer material is or includes very low density polyethylene plastomer, polyether/polyester block copolymer, or a polypropylene/EPDM blend.

14. A article according to any preceding claim, whose tubular length is less than its largest outer diameter, preferably less than half, more preferably less than one quarter, of its largest outer diameter.

15. A article according to claim 14, which has been cut from a longer length of the tubular article.

16. A article according to claim 14 or 15 in use as a gasket between opposed pressure surfaces, or in use as a grommet on an elongate object passing through the article.

17. A article according to any preceding claim, arranged with one of its ends in endwise abutment with its own other end or with an end of another such article, wherein the said sealant material (preferably sealant) is present at both of the said abutting ends and seals them together, preferably without any additional means attaching the ends to each other.

18. A free-standing article comprising an elongate tubular, filamentary, or rod-like carrier carrying an elongate body of mastic or pressure-sensitive adhesive sealant material which encloses more than 50%, preferably more than 75%, more preferably substantially all, of the perimeter of the carrier as viewed in transverse cross-section.

19. An article according to claim 18, wherein either the carrier, or the body of sealant, or both, has or have a substantially oval or round cross-sectional shape.

20. An article according to claim 18 or 19, wherein the or each carrier is a mono-filament of glass or plastics material, or a fibrous string or rope.

21. An article according to any of claims 18 to 20, wherein the body of sealant has been melt-coated, preferably extruded, around the carrier(s).

22. An article according to any of claims 18 to 21, wherein the sealant has been cross-linked after placement on the carrier.

23. An article according to any of claims 18 to 22, wherein the carrier is substantially continuous and substantially free of voids.

24. An article according to any of claims 18 to 23, wherein the carrier comprises a filament or yarn, preferably of glass, coated with plastics material of lower Young's modulus and/or higher elongation to break than the said filament or yarn.

25. An article according to claim 24, wherein the carrier is a glass monofilament or multi-filament yarn coated with a polyolefin, preferably low-density polyethylene.

26. An article according to claim 24 or 25, wherein the plastics material with which the filament or yarn is coated is one to which the sealant adheres more strongly than the sealant adheres to itself on surface-to-surface contact.

27. An article according to any of claims 18 to 23, wherein the carrier comprises a spring, preferably a coil spring.

28. An article according to claim 27, wherein the carrier is a coil spring and is embedded and enclosed in a solid body of the sealant which substantially fills the interior space of the coil.

29. An article according to claim 27, wherein the carrier is a coil spring and is enclosed by a hollow tube of the sealant.

30. An article according to claim 29, wherein the spring is at least partly embedded within the wall of the sealant tube.

31. An article according to any of claims 27 to 30, wherein the spring is made of metal.

32. An article according to any of claims 18 to 23, wherein the carrier is a metal wire, with or without a plastics coating thereon.

33. An article according to claim 32, wherein the bend modulus of the wire is sufficiently low for the article to be permanently bent without causing the wire to protrude through the sealant.

34. An article according to any of claims 18 to 23, wherein the carrier is stranded metal wire or rope.

35. An article according to any of claims 18 to 23, wherein the carrier is a braid, knit, weave or other fabric-like assembly of plastics or metal filaments.

36. An article according to any preceding claim, wherein the sealant is carried on an elongate carrier of sufficient flexibility to enable the article to be wound at least 90^0, preferably 180^0, around a circular shaft of diameter 100 cm, preferably 50 cm, more preferably 25 cm, especially 10 cm, without breaking the carrier.

37. An article according to any preceding claim, wherein the carrier includes a formation, preferably integral with the carrier, for attaching the carrier to an object which is to carry the article in use.

38. An article comprising an elongate tubular, filamentary, or rod-like carrier carrying an elongate body of sealant and including a formation, preferably integral with the carrier, for attaching the carrier to an object which is to carry the article in use.

39. An article according to claim 37 or 38, wherein the said formation comprises a projection with an enlarged region receivable in use in an aperture in the said object to anchor the carrier thereto.

40. An article according to any of claims 37 to 39, wherein the said formation is hollow.

41. An article according to claim 40, wherein said formation is integral with the carrier and the hollow within the said formation communicates with the hollow within the carrier.

42. A article according to any preceding claim, wherein the perimeter of the tubular body of sealant material extends only partly around the carrier, thus forming an open-sided tubular body of the sealant material.

43. An article according to any preceding claim, wherein the carrier comprises polysiloxane elastomer material.

44. An article according to any preceding claim in use as a door or window seal.

45. An article according to any preceding claim in use as a bath seal or wash-basin seal, or in use as a barrier to prevent moisture or other fluid from running down a sloping or vertical surface.

46. A method of forming a article according to any preceding claim, comprising applying a closed or open-sided tubular layer of the said sealant material in a molten state to the said carrier and causing or allowing the applied sealant material to solidify.

47. A method according to claim 46, comprising extruding the carrier and applying the sealant material thereto during or immediately after the extrusion of the carrier, preferably by co-extrusion with the carrier.

48. A method according to claim 46, comprising extruding the sealant material onto a pre-formed carrier, preferably after warming the carrier surface.

49. A method of forming a seal between a first body and a second body comprising placing a article according to any of claims 1 to 43 in contact with a portion of the first body and bringing a portion of the second body into compressive contact with the article so as to compress that article between the first and second bodies.

50. A housing component for electrical or other apparatus the housing component carrying a article according to any of claims 1 to 43 and the article being positioned on the housing component so as to form a seal between the housing component and another body with which the housing component will be assembled in use, preferably with compression of the article.

51. A housing component according to claim 50, carrying the article in a channel arranged to receive a mating part of the said other body in use to form a sealed connection, preferably a tongue-and-groove type of connection.

52. A housing component according to claim 50 or 51 assembled together with the said other body.

53. A kit of parts comprising a housing component and a article capable of being assembled to provide a housing component according to claim 50 or 51.

54. A kit according to claim 53, additionally comprising another body, preferably a second housing component, capable of assembly together with the said housing component to compress the said article to form a seal between the said housing component and the said other body.

55. A kit of parts comprising a door or window component and an article according to any of claims 1 to 43 capable of acting as a seal in a door or window assembly to be formed using the said kit.

56. A door or windor component carrying an article according to any of claims 1 to 43.

57. A profile comprising an elongate carrier having a fixing adhesive on part of its external perimeter and sealant, preferably mastic or gel or adhesive (possibly the same as the fixing adhesive), on part or all of the remainder of its perimeter (as seen in end view).

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Fig.1.

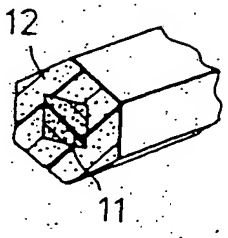


Fig.2.

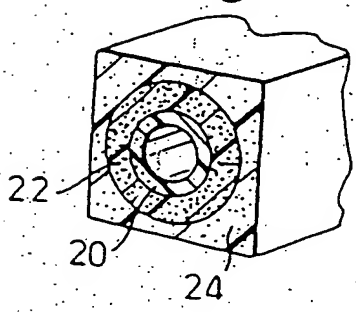


Fig.3A.

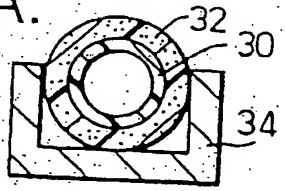


Fig.3B.

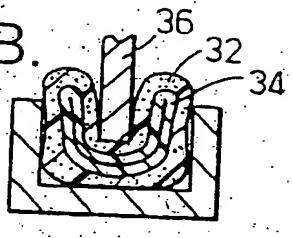


Fig.3C.

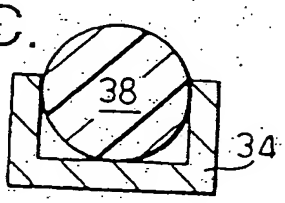


Fig.3D.

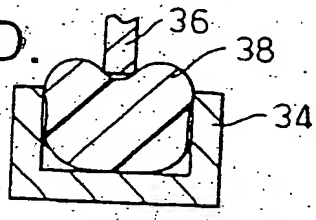


Fig.4A.

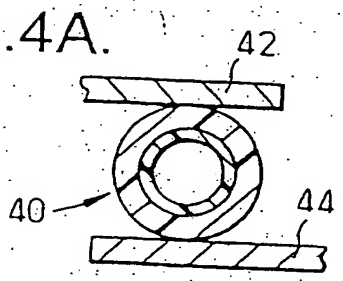


Fig.4B.

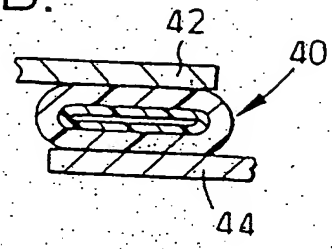


Fig.4C.

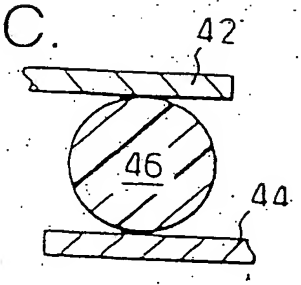


Fig.4D.

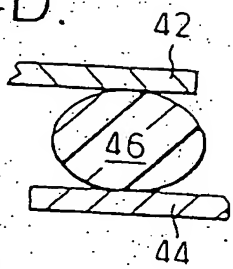


Fig.5A.

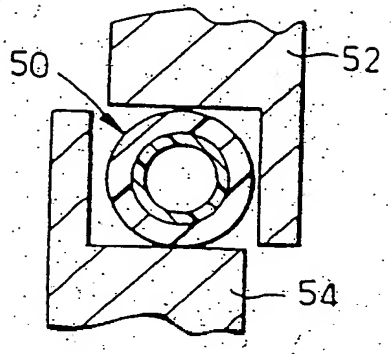


Fig.5B.

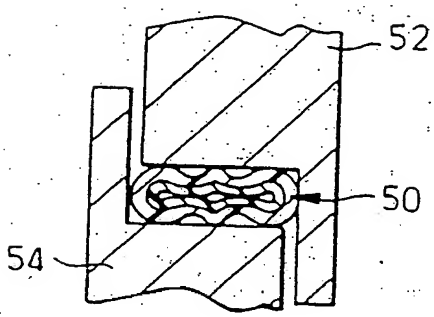


Fig.6.

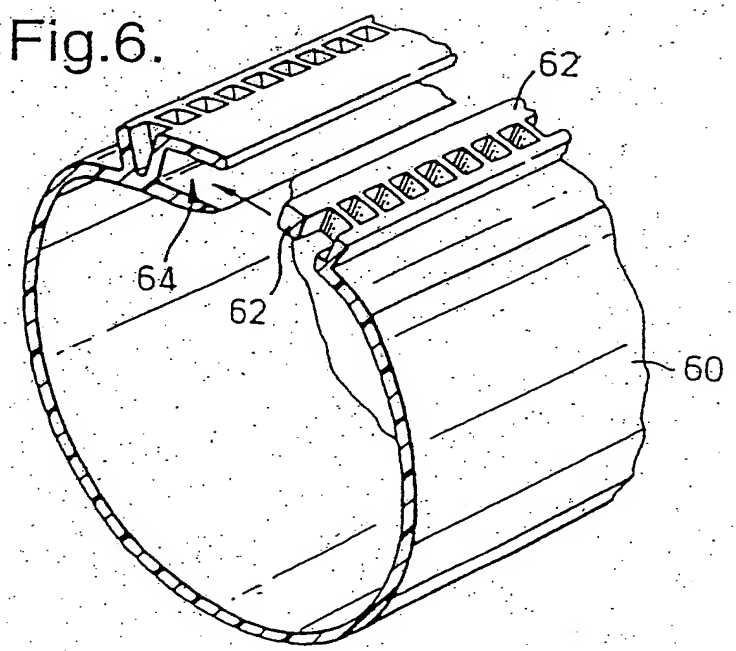


Fig.7A.

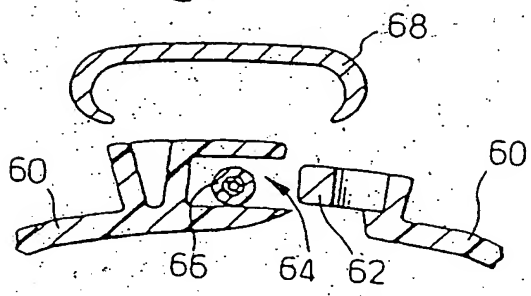
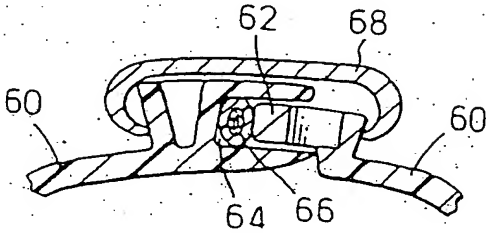


Fig.7B.



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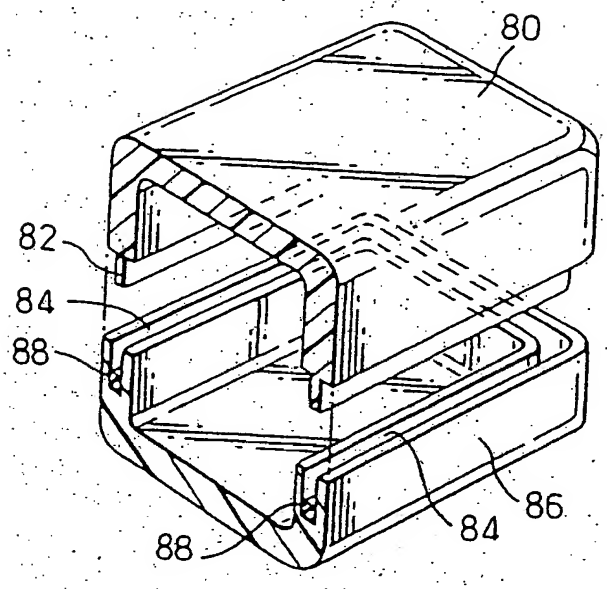


Fig.8B.

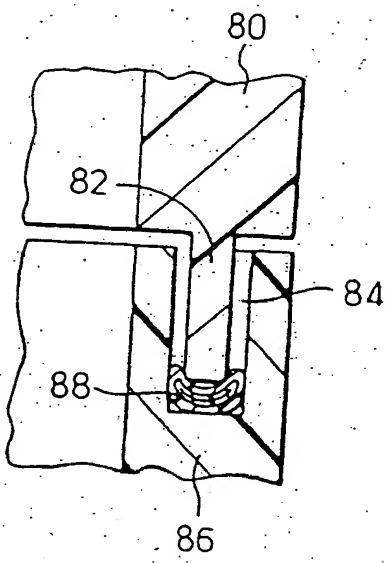
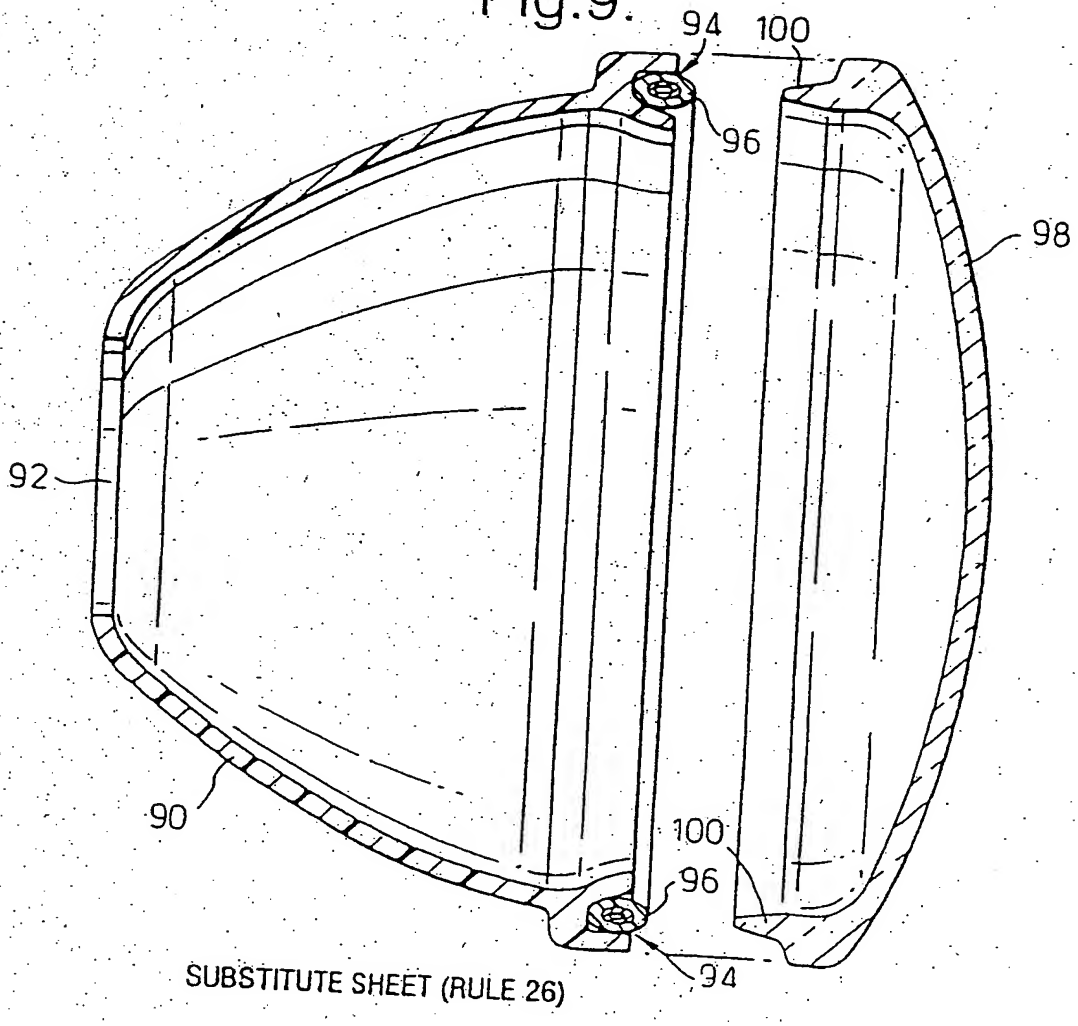


Fig.9.



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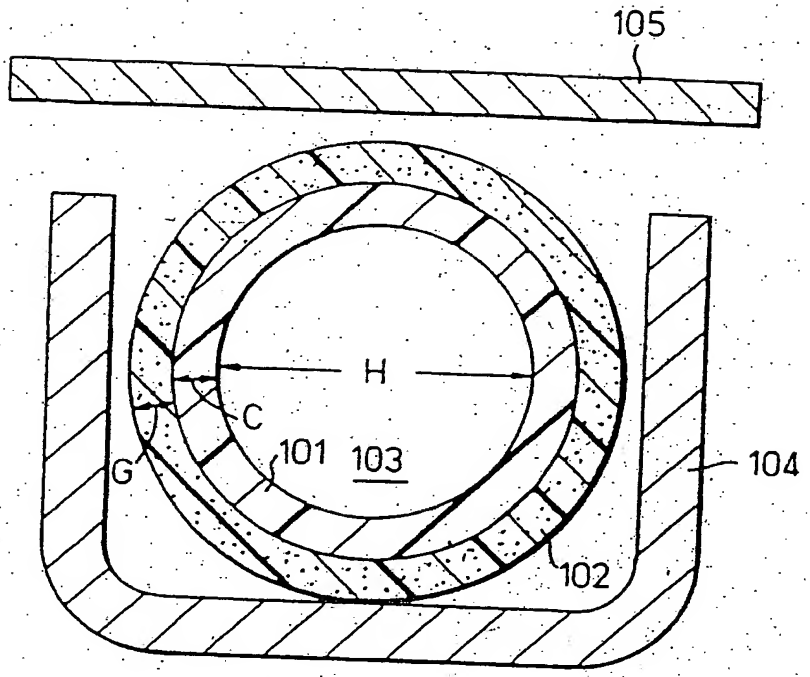

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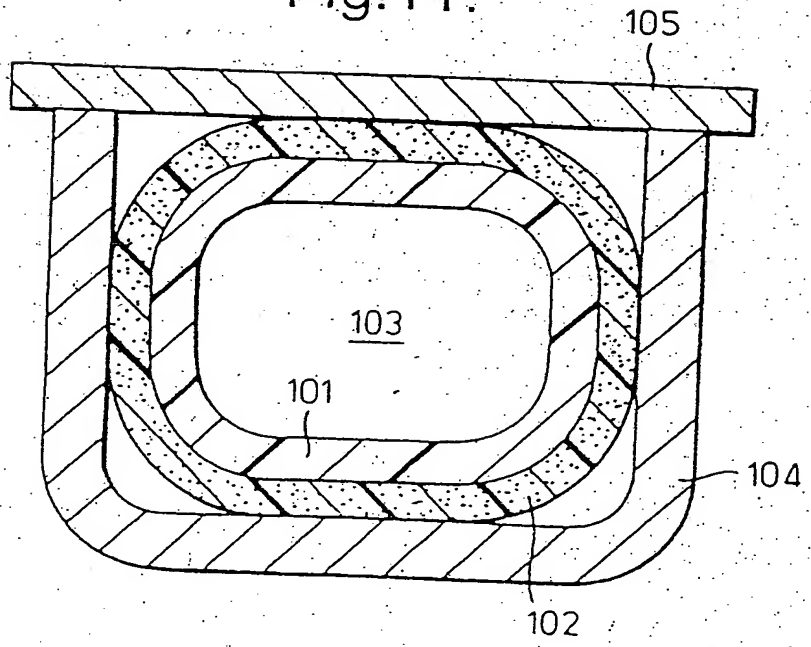

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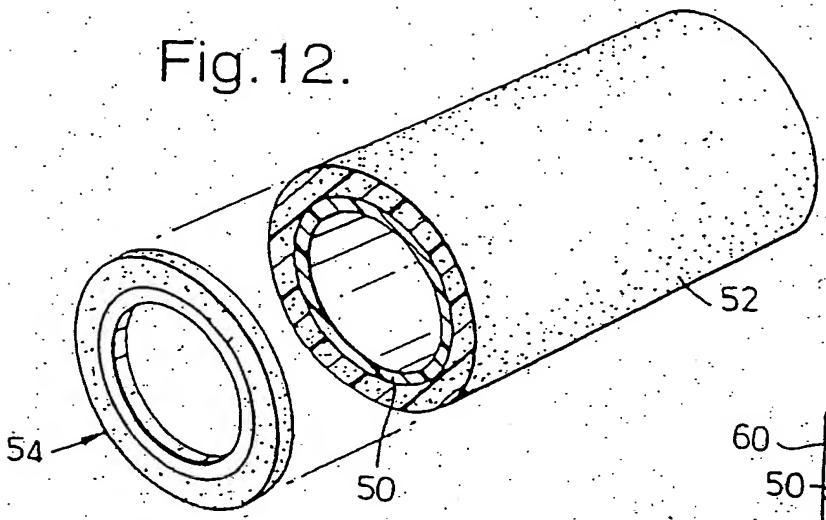

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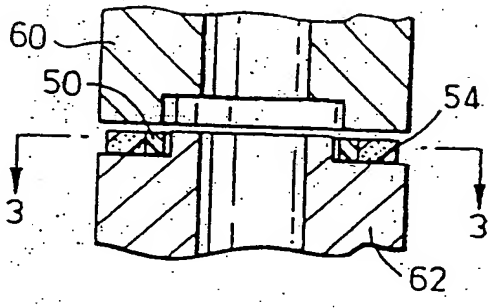


Fig.14.

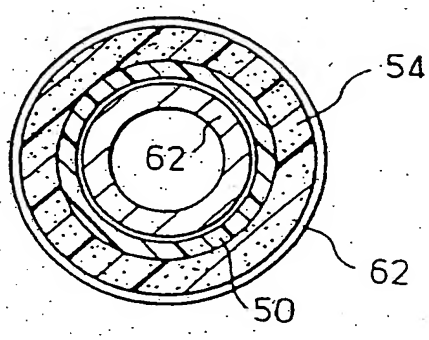
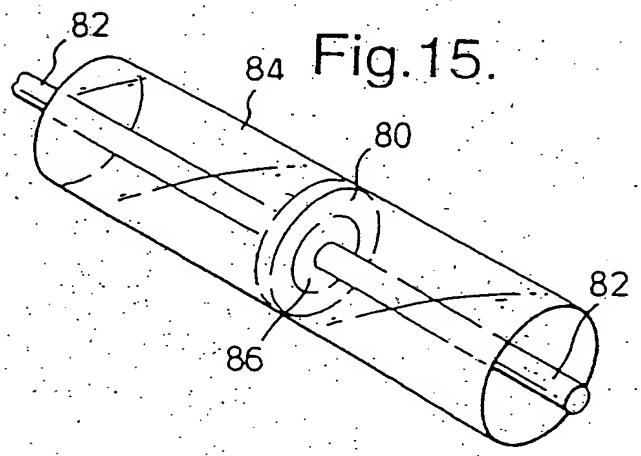


Fig.15.



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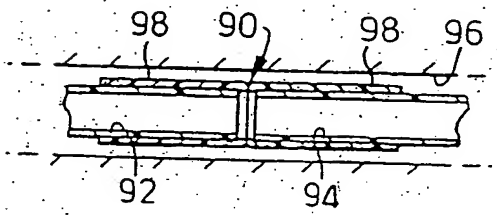

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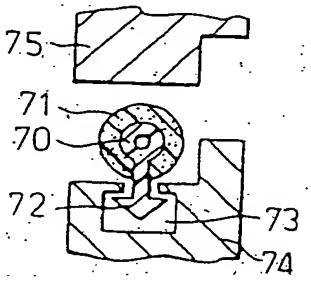

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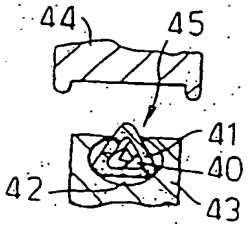


Fig.19

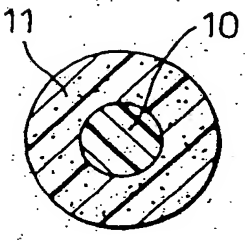


Fig.20

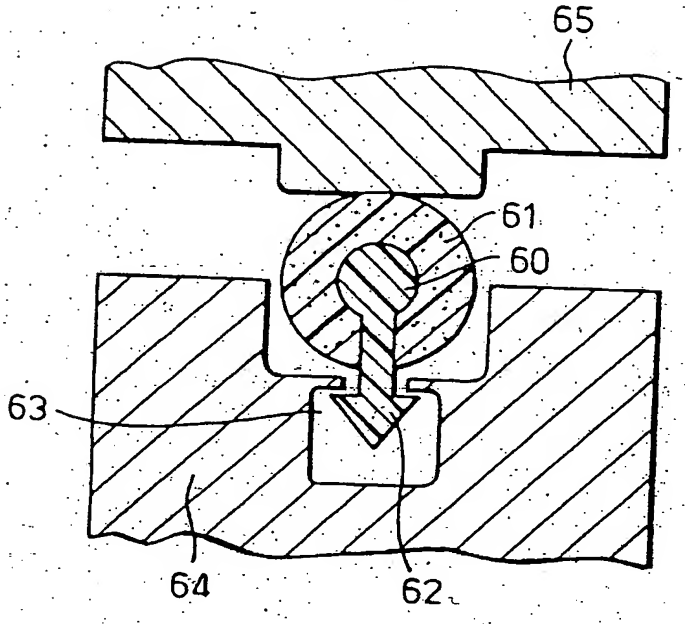


Fig. 21

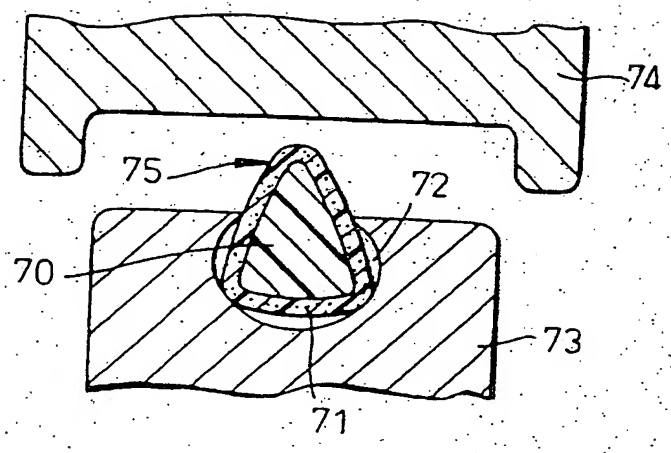


Fig. 22

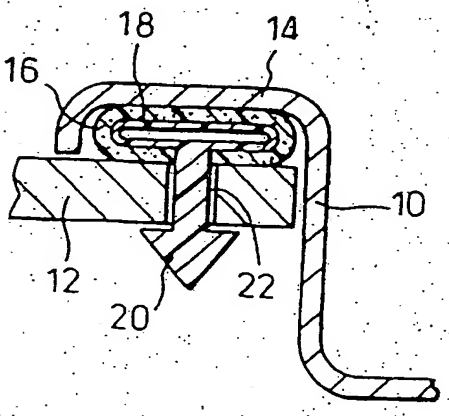
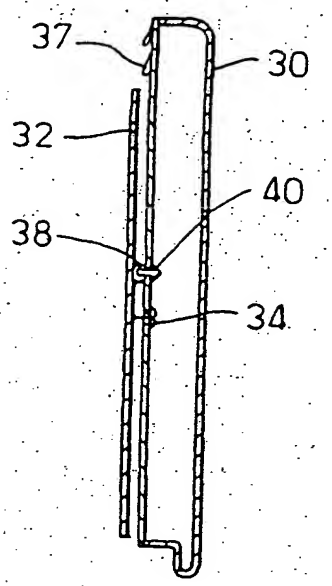
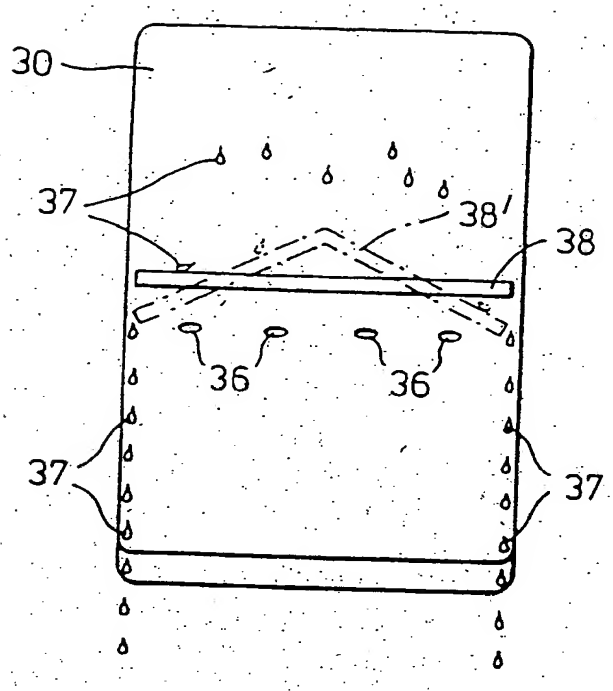


Fig. 23





INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 97/00776

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F16J15/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F16J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 97 07350 A (RAYCHEM) 27 February 1997 see the whole document	1-57
X,P	WO 96 09483 A (RAYCHEM) 28 March 1996 see abstract; claims 11-13; figures	1,11-13
X,P	WO 96 18836 A (RAYCHEM) 20 June 1996 see abstract; figures	1,2,4-6
X	PATENT ABSTRACTS OF JAPAN vol. 8, no. 26 (M-273), 3 February 1984 & JP 58 184361 A (NISSAN), 27 October 1983, see abstract	1-5, 17-19, 49,50,57
X	EP 0 275 171 A (RAYCHEM) 20 July 1988 see column 3, line 21 - column 4, line 27; figures	18-20

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 June 1997	04 07 97
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Authorized officer Narminio, A

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 97/00776

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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